IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF APPEALS AND INTERFERENCES

Application No.:	10/730,398
Filing Date:	December 8, 2003
Appellant:	Bieler et al.
Group Art Unit:	1742
Confirmation No.:	6179
Examiner:	Sikyin Ip
Title:	METHODS FOR PRODUCING LEAD-FREE IN-SITU COMPOSITE SOLDER ALLOYS
Attorney Docket:	6550-000013/COA

MS Appeal Brief – Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

APPEAL BRIEF UNDER 37 C.F.R. § 41.37
AND PETITION FOR EXTENSION OF TIME

Dear Sir:

This is an appeal from the Office Action mailed July 16, 2007, finally rejecting Claims 20-62. A Notice of Appeal was filed on January 15, 2008 appealing all of the rejected claims. With a three-month extension pursuant to 37 C.F.R. §1.136(a) and §41.37(e), this Brief is due on June 15, 2008.

This Brief is accompanied by the required fees under 37 C.F.R. § 41.20(b)(2) and 37 C.F.R. §1.17(a).

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I. REAL PARTY IN INTEREST

The real party in interest is the Board of Trustees Operating Michigan State University. An assignment from the inventors to assignee, Board of Trustees Operating Michigan State University, was executed in the parent case, U.S. Patent Application Serial No. 09/114,665, on June 12, 1998 and June 17, 1998, and recorded with the U.S. Patent and Trademark Office at Reel 9324, Frame 0836.

II. RELATED APPEALS, INTERFERENCES AND JUDICIAL PROCEEDINGS

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

Claims 20-62 are finally rejected. Claims 1-19 were cancelled. The claims on appeal are Claims 20-62.

IV. STATUS OF AMENDMENTS

No amendments to the claims were submitted after final rejection.

V. SUMMARY OF CLAIMED SUBJECT MATTER

The rejected Claims 20-62 include three independent claims, namely Claims 20, 39 and 54, which are generally directed to methods for producing *in-situ* lead-free composite solders. *[P. 5, ll. 4-7.]* In various aspects, the inventive methods of all of the rejected Claims 20-62 form *in-situ* composite solders comprising a matrix of eutectic or near-eutectic lead-free solder and an intermetallic component homogenously distributed throughout the matrix solder to form a composite solder. *[P. 5, ll. 5-10.]* Such lead-free composite solders have improved mechanical properties, such as improved resistance to thermal fatigue damage. *[P. 1, ll. 5-7; p. 4, ll. 29-35; p. 6, ll. 20-33.]* Independent Claims 20, 39, and 54 commonly recite that the intermetallic component is present at greater than about 10 volume % in the composite solder and components of the intermetallic component are selected so as to have a density within 10% of the density of the solder matrix. *[P .7, l. 35 - p. 8, l. 6; p. 9, ll. 13-17.]* Each independent claim, as well as each separately rejected dependent claim, is discussed in more detail below.

<u>Independent Claim 20 and Dependent Claims 21-24, 27-33, and 36-37</u>

Independent Claim 20 recites a method for producing an *in-situ* composite solder having an intermetallic component comprising the steps of:

(a) providing a mixture comprising the components of a eutectic or near-eutectic matrix solder and the components of an intermetallic component present at greater than or equal to about 10 volume % and less than or equal to about 95 volume %. *[P. 5, ll. 5-10; p. 7, ll. 21-31; p. 9, ll. 13-17.]* As noted above, the intermetallic component is selected to have a density within 10% of a density of said eutectic or near-eutectic matrix solder. *[P. 7, l. 35 - p. 8, l. 6.]* The method of Claim 20 further includes:

(b) heating the mixture of components of the matrix and intermetallic components, so as to melt all components of the mixture to form a non-solid mixture; *[P. 6, ll. 11-12; p. 7, ll. 9-11; p. 10, ll. 9-11]* and

(c) cooling the non-solid mixture at a rate sufficiently fast so as to form the intermetallic components having a particle size of less than about 10 microns and such that the intermetallic components are homogenously distributed throughout the matrix solder to form the composite solder. *[P. 5, ll. 7-8; p. 6, ll. 12-14; p. 7, ll. 11-21; p. 9, ll. 3-12; p. 11, ll. 16-20.]* Claims 21-24, 27-33, and 36-37 depend upon Claim 20 and stand rejected for the same reasons and over the same prior art.

<u>Dependent Claims 25-26, 34-35 and 38</u>

Claims 25-26, 34-35, and 38 each depend upon Claim 20, discussed above, however, were separately rejected over the prior art. Claims 25 and 26 provide an intermetallic component respectively comprising Ni_3Sn_4 or $FeSn_2$ formed in accordance with the methods of Claim 20. *[P. 12, ll. 1-3 and 30-35; Figures 3B-3C.]*

Claim 34 specifies that the intermetallic component comprises about 10% to about 20% by volume of the composite solder formed in accordance with the method of Claim 20. *[P. 9, ll. 15-17.]* Claim 35 recites that the intermetallic component comprises about 20% by volume of the composite solder. *[P. 9, ll. 16-17.]*

Lastly, Claim 38 further comprises the method of Claim 20, where the cooling is done by spat quenching, spray atomization, or by continuous casting into a solid form. *[P. 7; ll. 14-19; p. 10, l. 27 - p. 11, l. 9.]*

Independent Claim 39 and Dependent Claims 40-45 and 47-53

Independent Claim 39 recites a method for producing an *in-situ* composite solder having an intermetallic component, similar to the features of Claim 20, discussed above. Independent Claim 39 shares several common aspects with Claim 20, including:

(a) providing a mixture comprising the components of a matrix solder and the components of the intermetallic component; *[P. 5, ll. 5-10; p. 7, ll. 21-31; and p. 9, ll. 13-17.]*

(b) heating the mixture so as to melt all components of the mixture to form a non-solid mixture; *[P. 6, ll. 11-12; p. 7, ll. 9-11; p. 10, ll. 9-11]* and

(c) cooling the non-solid mixture at a rate sufficiently fast so as to form a composite solder where the intermetallic components have a particle size of less than about 10 microns and are homogenously distributed throughout the matrix solder. *[P. 5, ll. 7-8; p. 6, ll. 12-14; p. 7, ll. 11-21; p. 9, ll. 3-12; p. 11, ll. 16-20.]*

However, Claim 39 further specifies that the components of the intermetallic component are provided in amounts appropriate to form a solder having from about 10% to about 40% by volume of the intermetallic component. *[P.9, ll. 15-16.]* Dependent Claims 40-45 and 47-53 stand rejected on the same grounds as Claim 39, from which they depend.

Dependent Claim 46

Claim 46, which depends upon Claim 39 above, stands separately rejected over the prior art. Claim 46 recites a similar method as dependent Claim 38, discussed above, where cooling is done by spat quenching, spray atomization, or by continuous casting into a solid form. *[P. 7; ll. 14-19; p. 10, l. 27 – p. 11, l. 9.]*

Independent Claim 54 and Dependent Claim 60

Independent Claim 54 recites a method for producing an *in-situ* composite solder having an intermetallic component, comprising the steps of:

(a) providing a binary or ternary eutectic or near eutectic matrix solder; *[P. 5, ll. 5-10; p. 7, ll. 21-31; and p. 9, ll. 13-17.]*

(b) heating a mixture of the matrix solder with the components of an intermetallic component at a temperature greater than the highest melting temperature of all of the individual components of the mixture so as to form a non-solid mixture. *[P. 6, ll. 11-12; p. 7, ll. 9-11; p. 10, ll. 9-11.]* The intermetallic components comprise a first row transition metal; *[P. 7, ll. 34-35.]*

(c) rapidly cooling the non-solid mixture. *[P. 5, ll. 7-8; p. 6, ll. 12-14; p. 7, ll. 11-21; p. 9, ll. 3-12; p. 11, ll. 16-20.]* The composite solder comprises from about 10% to about 40% by volume of the intermetallic component, as also recited in Claim 39. *[P. 9, ll. 15-17.]* However, Claim 54 further recites that the intermetallic component comprises at least one element present in the matrix solder. *[P. 8, ll. 1-2.]* Similar to Claims 20 and 39, the intermetallic component comprises particles having a particle size of less than about 10 microns homogenously distributed throughout the composite solder, and the intermetallic component is selected to have a density within 10% of a density of the matrix solder; *[P. 5, ll. 7-8; p. 6, ll. 12-14; p. 7, ll. 11-21; p. 8, ll. 1-4; p. 9, ll. 3-17; p. 11; ll. 16-20.]*

The method of Claim 54 further includes:

(d) heating the composite solder to a temperature that is greater than a melting point of the matrix solder and less than a melting point of the intermetallic component, wherein the heating melts only the matrix solder; *[P. 12, ll. 17-23]* and

(e) cooling and solidifying the composite solder to form a solder joint. *[P. 11, ll. 31-35; p. 12, ll. 3 and 15-24; Figures 3A-3C.]* Composite solders used in accordance with the invention of Claim 54 form a composite solder joint having a greater solder joint strength, creep resistance, and fatigue resistance than a comparative solder joint formed from a eutectic or near-eutectic solder. *[P. 3, ll. 17-24; p. 13, ll. 1-23; Figure 4].* Dependent Claim 60 stands rejected over the same prior art as independent Claim 54.

<u>Dependent Claims 55-59 and 61-62</u>

Dependent Claims 55-59 and 62, which either directly or indirectly depend upon independent Claim 54, stand separately rejected over the prior art. Claims 55-56 recite the particle size of the intermetallic component is less than 5 microns or 2 microns, respectively. *[P. 9, ll. 7-8; p. 11, ll. 16-20, 27-31.]* Dependent Claims 57-59 specify that the components of the intermetallic component include a metal selected from the group consisting of nickel, iron, copper, and mixtures thereof, for example. *[P. 9, ll. 18-35.]* Claim 58 specifies that the intermetallic component is selected from: Cu_6Sn_5, Ni_3Sn_4, $FeSn_2$, and mixtures thereof. *[P. 7, ll. 6-7; p. 9, ll. 18-35; p. 12, ll. 1-3, 30-35; Figures 3A-3C.]* In Claim 59, the matrix solder is 96.5 Sn/3.5 Ag. *[P. 7, ll. 5-7, 23-25; p. 11, ll. 21-31; Figures 2A-2B.]* Dependent Claim 61 recites a cooling step done by splat quenching, spray atomization or by continuous casting into a solid form, similar to Claims 38 and 46 above. *[P. 7, ll. 14-19; p. 10, l. 27 - p. 11, l. 9.]*

Dependent Claim 62 recites an additional step between heating (b) and cooling (c), where the mixture is cooled to form a solid and the solid is remelted at a temperature sufficient to melt all of the components of the solid. *[P. 10, ll. 19-30.]*

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1. Whether Claims 20-24, 27-33, 36, 37, 39-45, 47-53, 55-59, and 62 are unpatentable under 35 U.S.C. § 103 over U.S. Patent No. 5,527,628 to Anderson et al., issued June 18, 1996 (herein "*Anderson*").

2. Whether Claims 25, 26, 38, 46, and 61 are unpatentable under 35 U.S.C. § 103 over *Anderson* in view of U.S. Patent No. 5,520,752 to Lucey, Jr. et al., issued May 28, 1996 (herein "*Lucey*").

3. Whether Claims 34, 35, 54, and 60 are unpatentable under 35 U.S.C. § 103 over *Anderson* in view of "*Issues Regarding Microstructural Coarsening Due to Aging of Eutectic Tin-Silver Solder*," by A.W. Gibson et al., Des. Reliab. Solders Solder Interconnect, Proc. Symp., pp. 97-103 (1997) (herein "*Gibson*").

VII. ARGUMENT

A. The Scope and Content of the Prior Art's Teachings Fail to Support a *Prima Facie* Case of Obviousness for Claims 20-24, 27-33, 36, 37, 39-45, 47-53, 55-59, and 62.

The obviousness rejection of Claims 20-24, 27-33, 36, 37, 39-45, 47-53, 55-59, and 62 on appeal relies upon a single reference, *Anderson*, for teaching a eutectic or near-eutectic tin-silver-copper lead-free solder. In properly establishing a *prima facie* case of obviousness per *Graham v. John Deere Co.,* the objective scope and content of the entire body of prior art must be considered, which is then compared to the claimed invention to make a proper obviousness determination.[1] It is improper for an obviousness rejection to be based upon selective teachings in the art, while ignoring other relevant teachings of the art. *See Akzo N.V. v. Int'l Trade Comm.*, 808 F.2d 1470, 1 USPQ.2d 1241, 1246 (Fed. Cir. 1986) ("Prior art references before the tribunal must be read as a whole and consideration must be given where the references diverge and teach away from the claimed invention.") In the present circumstance, the Examiner's obviousness rejection is flawed because the Examiner neglects to consider the entire scope and content of the prior art's teachings, which *in toto* leads those of skill in the art away from arriving at the claimed invention.

The Scope and Content of the Prior Art Limits *Anderson*'s Contribution to the Art

The scope and content of relevant art informs the relative contribution of the *Anderson* patent to the field. While *Anderson* allegedly teaches a eutectic Sn-Ag-Cu composition, it is widely recognized by the other teachings of the prior art as being wholly based on a conversion

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[1] A §103 analysis requires ascertaining, i) the scope and content of the prior art; ii) differences between the prior art and the claims at issue; and iii) the level of ordinary skill in the pertinent art. *Graham v. John Deere Co. of Kansas City,* 383 U.S. 1 (1966). "Against this background the obviousness or nonobviousness of the subject matter is determined." *KSR Int'l Co. v. Teleflex Inc.,* 127 S.Ct. 1727, 1729-30 (2007).

error. Then references -- which were ignored by the Examiner -- establish that *Anderson* sets forth an erroneous eutectic Sn-Ag-Cu solder (93.6 Sn - 4.7 Ag – 1.7 Cu wt. %). *See* Evidence Appendix, *infra* (37 C.F.R. §1.132 Declaration of Dr. Bieler ("*1.132 Declaration*") at ¶¶ 5-7) and the Moon et al., "Experimental and Thermodynamic Assessment of Sn-Ag-Cu Solder Alloys," J. of Elec. Materials, Vol. 29, No. 10, Pp. 1122-1136 (2002) (hereinafter "*Moon*"). *Moon*, in particular, states "Miller et al. [inventors of *Anderson*], using DTA, found a ternary eutectic at 217°C ... [with a] ... composition at 4.7 wt.% Ag, 1.7 wt.% Cu. A patent [*Anderson*] was issued based on this work... An error was made in the conversion from atomic to weight % conversion by Miller et al. The composition obtained from the initial estimate was Sn – 3.25 wt.% Ag – 0.69 wt.% Cu." (*Moon*, at pp. 1122, 1123).[2] Moreover, these errors have been acknowledged by co-inventors of *Anderson*, themselves, in a subsequent article.[3] Thus, the eutectic compositions set forth in the *Anderson* patent are erroneous and should in fact have reflected lower concentrations of silver and copper. *See e.g., §1.132 Declaration* at ¶¶ 5-7; *Moon*, at 1122-23.

Nevertheless, the Examiner has relied solely upon *Anderson*, while ignoring this highly relevant information in the art which speaks to the limited scope of *Anderson's* teachings. In the Final Office Action at p. 5, ll. 17-18, the Examiner stated that the *Moon* and *Anderson* references, as well as the *1.132 Declaration* are "immaterial because examples of the cited reference are given by way of illustration and not by way of limitation." The Examiner cited no other prior art, however, that would provide an apparent reason to modify the alleged

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[2] Submitted in Information Disclosure Statement filed on June 9, 2006.

[3] *Anderson*, et al., "Microstructural Modifications and Properties of Sn-Ag-Cu Solder Joints Induced By Alloying," J. of Elec. Materials, Vol. 31, No. 11 (2002), p. 1166, 1167 and footnote 6 ("*Anderson Article*"), submitted in Information Disclosure Statement filed on June 9, 2006.

"illustrative" eutectic compositions in *Anderson* to correct this error and arrive at the claimed invention.

A similar issue was addressed in *In re Yale*, where the claims were rejected for being obvious over a primary prior art reference that set forth a compound ($CF_3CF_2CHClBr$) that was alleged to be a typographical error. *In re Yale*, 434 F.2d 666, 667 (C.C.P.A. 1970) (where the Board of Patent Appeals and Interferences upheld the obviousness rejection, because the alleged error in the primary reference was not apparent on the face of the document and one of skill in the art would not know of the error and thus would still be taught that the compound was an anesthetic.) The court reversed the rejection, stating that the listing of the erroneous compound in the primary reference was an error obvious to one of ordinary skill in the art, so that the reference did not describe or suggest the erroneous compound to those in the art. *Id.* at 668-669. Since the prior art contained an obvious error, the court stated that one of ordinary skill in the art would not do anything more than mentally disregard the erroneous compound as a misprint or mentally substitute the correct compound in its place. *Id.* In sum, the court held that the public was not put in possession of the erroneous compound; thus, it would not be obvious to use such a compound as an inhalant anesthetic as claimed and did not render the invention obvious. *Id.* at 669; See also, MPEP §§ 716.07 and 2121.

Similar to the *In re Yale* case, the *Anderson* patent sets forth erroneous eutectic compositions. The entire disclosure of *Anderson* is based upon calculation errors that provide inaccurate compositional ranges, which are far in excess of the true eutectic or near-eutectic composition ranges, as later acknowledged by the inventors in the *Anderson Article*. This art in the field objectively evidences these limitations of the *Anderson* patent. As such, the teachings of *Anderson* provide limited guidance to a skilled artisan and have negligible applicability to the presently claimed invention. Stated in another way, one of skill in the art would not look to

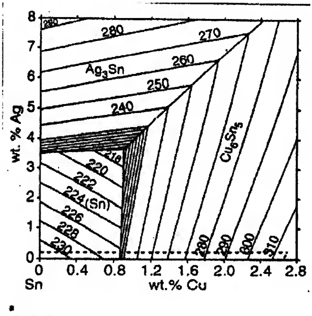
Anderson for guidance as a starting point in the art to select a eutectic or near-eutectic solder. Similar to the situation in *Yale*, those of skill in the art recognize the errors in *Anderson* and would be apt to mentally disregard the errors or to substitute the correct eutectic composition. The scope and content of the art reveals that *Anderson* only provides a minor contribution to the field and thus cannot sufficiently support a rejection of any of the claims; hence the obviousness rejections based upon *Anderson* should be reversed.

***Anderson* neither Describes nor Suggests Eutectic or Near-Eutectic Solder Compositions Having 10 Volume % Intermetallic Components**

Notwithstanding the deficiencies in its teachings, *Anderson* does not describe or suggest the claimed methods of producing a composite solder having an intermetallic component homogeneously distributed through a eutectic or near-eutectic matrix solder, where the intermetallic component is selected to have a density within 10% of the density of the matrix solder and is present at greater than or equal to 10 volume %. The density and particle size of the intermetallic components ensure that relatively high concentrations of intermetallic components remain homogeneously distributed, even when exposed to heat (*e.g*, through reflow and service use), thereby providing the requisite strengthening for a solder joint. *See* for example, Appellants' specification at P. 8, l. 1 to p. 9, l. 11.

The Examiner relies upon *Anderson* for allegedly providing a eutectic or near-eutectic matrix solder and intermetallic phase of Cu, Ag, and/or Sn to form a mixture. *See e.g.,* Final Office Action mailed July 16, 2007 at P. 2, ll. 28-30. The Examiner admits that *Anderson* fails to describe the claimed cooling rate or the size of the intermetallic particles. Final Office Action mailed July 16, 2007 at P. 2, l. 34 - p. 3, l. 1. The Examiner alleges that the erroneous ranges set forth in *Anderson* overlap with the claimed compositional ranges. This is not correct.

Anderson restricts the amount of copper present to less than 4.0 wt. %. Col. 5, ll. 22-24. This is notwithstanding the fact that *Anderson* sets forth incorrect weight percentages and that the <u>actual</u> eutectic or near-eutectic solder compositions should be significantly lower. In an exemplary eutectic or near-eutectic Sn-Ag-Cu solder having 10 vol. % percent of a Cu_6Sn_5 intermetallic (in accordance with the claimed invention) a total copper concentration is over 4.4 wt. % and the composition has a melting temperature in excess of 310°C. A Cu concentration in excess of only 2.6 wt. % (where Ag is about 0.2 wt. %) provides a liquidus melting temperature of 310°C per the ternary phase diagram in *Moon* at Figure 14(a) at P. 1131:



Thus, notwithstanding the limited scope of *Anderson*, even the erroneously high compositions set forth do not overlap with the claimed solder compositions. Further, a melting temperature in excess of 310°C is well above the range of acceptable melting temperatures specified by *Anderson*, thus teaching away from the concentrations of Cu and Ag that would be necessary for the claimed invention. For example, *Anderson* specifies that the solder should be less than 232°C and further states that a 260°C melting temperature is "far too great for

electronic soldering." Col. 2, ll. 5-8. As such, the Examiner is mistaken in asserting that there is overlap with the concentration of copper in the claimed solder composition and the compositions set forth in *Anderson.* The claimed amounts of intermetallic component present in a composite eutectic or near-eutectic solder far exceeds the minor concentrations disclosed in *Anderson.*

***Anderson* Teaches Away from the Examiner's Proposed Modifications, Which Would Render *Anderson* Inoperable for Its Stated Purpose**

Additionally, *Anderson* would be rendered inoperable for its stated purpose if modified in a manner suggested by the Examiner to arrive at the claimed invention and therefore *Anderson* teaches away from the claimed invention. "A reference may be said to teach away when a person of ordinary skill, upon reading the reference... would be led in a direction divergent from the path that was taken by the Appellant." *In re Kahn,* 78 USPQ.2d 1329, 1338 (Fed. Cir. 2006) citing *In re Gurley*, 31 USPQ.2d 1130 (Fed. Cir.1994). Non-obviousness is supported in situations where references teach away from the claimed invention. See e.g., *KSR Int'l Co. v. Teleflex Inc.,* 127 S.Ct. 1727, 1740 (2007). Furthermore, obviousness cannot be predicated on a combination of references that produces a seemingly inoperable device, in contravention to its stated objectives. *See e.g., McGinley v. Franklin Sports*, 262 F.3d 1339, 60 USPQ.2d 1001, 1010 (Fed. Cir. 2001) citing *In re Sponnoble*, 405 F.2d 578, 160 USPQ 237, 244 (CCPA 1969).

Anderson has an objective of providing a eutectic and/or near-eutectic solder that has a low melting point, specifically less than 217°C + 15° (*i.e.*, 232°C). Col. 4, ll. 55-65; Col. 5, ll. 5-12. *Anderson* thus discloses a very specific narrowly defined eutectic composition, which sets forth an object of having the lowest possible melting temperature nearing the eutectic point. Hence, as recognized by those of skill in the art, adding a significant concentration of one or more elements to form an intermetallic component at greater than 10 vol. % would impermissibly increase the melting temperature and/or "liquid-solid mushy zone" to far beyond

232°C. For example, a Sn-Cu alloy having 10 vol. % of a Sn_6Cu_5 intermetallic component has a melting point of greater than about 375°C.[4]

Hence, if intermetallic components were present in *Anderson* at greater than 10 vol. %, a melting temperature of such a solder would be in excess of 310 °C, which is far outside the ambit of a eutectic or near-eutectic composition (in contravention to the object of *Anderson* to have a eutectic or near-eutectic composition). *See e.g.*, Col. 5, ll. 4-12. Thus, modifying the compositions of *Anderson* to include intermetallic components at 10 vol. % would contravene the stated objectives of *Anderson*, to make it inoperable for its stated purpose.

Anderson fails to describe or to provide any apparent reason to one of skill in the art to begin with a eutectic or near-eutectic solder matrix and add intermetallic components at relatively high concentrations (greater than 10 vol. %), which then significantly depart from a eutectic or near-eutectic composition. Similarly, *Anderson* fails to provide an apparent reason to

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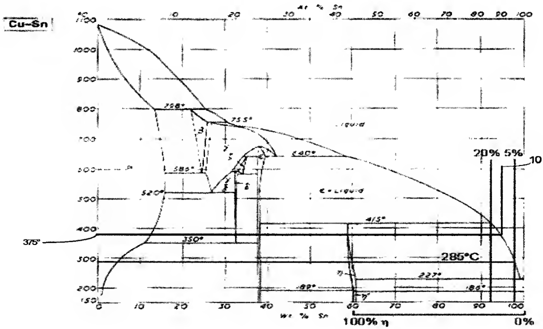
[4] *See e.g.*, Exhibit A of Office Action Response dated April 28, 2003 submitted in parent application U.S.S.N. 09/114,665 - Smithells Metals Reference Book, 7[th] edition, Butterworth Heinemann, Oxford, 11-242 (1992).



arrive at a method where a small particle size of intermetallic component (less than about 10 μm) is ensured via the specific heating and cooling steps conducted, and further by selecting components for an intermetallic component where the density is similar to that of the solder matrix (within about 10%). The density and particle size of the intermetallic components ensure that relatively high concentrations of intermetallic components remain homogeneously distributed, even when exposed to heat (*e.g*, through reflow and service use), thereby providing the improvement in strength for a solder joint. *See* for example, Appellants' specification at P. 8, l. 1 to p. 9, l. 11.

In sum, a *prima facie* case of obviousness has not been established for independent Claims 20 and 39, or their respective dependent claims. The scope and content of the prior art informs the relative and limited contribution of *Anderson* to the pertinent art, which due to widely recognized errors is insufficient to describe or suggest the claimed invention. As such, the obviousness rejection of Claims 20-24, 27-33, 36, 37, 39-45, 47-53, 55-59, and 62 should be reversed.

B. Claims 25, 26, 38, 46, and 61 are Not Obvious Over the Combination of *Anderson* and *Lucey*).

Claims 25, 26, and 38 (which ultimately depend upon independent Claim 20); Claim 46 (which depends upon independent Claim 39); and Claim 61 (which depends upon independent Claim 54) are not rendered obvious by the combination of *Anderson* with *Lucey*. For the reasons set forth above, the *Anderson* reference is deficient and fails to render independent Claims 20 and 39 obvious. Claim 54 shares common features with Claims 20 and 39 and as such, is similarly patentably distinguishable over *Anderson*. Similarly, the *Lucey* reference fails to disclose or suggest the methods claimed in any of Claims 25, 26, 38, 46, or 61, nor does *Lucey* provide any apparent reason to arrive at such claimed methods, where components of an

intermetallic are added to a pre-formed solder matrix. *Lucey* merely describes adding premade commercial filler particles to bulk or paste solders. *See e.g.,* Col. 2, ll. 12-16; Col. 3, ll. 35-40. *Lucey* does not disclose melting components of intermetallic particulates so as to form a mixture of the solder and intermetallic component. Hence, *Lucey* does not account for the deficiencies of *Anderson* discussed extensively above, and as such Claims 25, 26, 38, 46, or 61 are not rendered obvious by the combination of *Anderson* with *Lucey.* Accordingly, the rejection should be reversed.

C. Claims 34, 35, 54, and 60 are Non-Obvious over the Prior Art because a Combination of *Anderson* with *Gibson* Teaches Away from the Claimed Invention.

Independent Claim 54 provides a method having similar features to independent Claims 20 and 39 discussed above, and further includes distinct steps of (d) heating the composite solder to a temperature greater than a melting point of the matrix solder, but to a temperature less than the melting point of the intermetallic component, thereby melting only the matrix solder. Then the composite solder is (e) cooled and solidified to form a solder joint. Upon cooling, the solidified composite solder forms a solder joint having superior physical properties, including greater solder joint strength and greater creep and fatigue resistance than a comparative solder joint formed from a eutectic or near-eutectic solder alone, such as that described in *Anderson.* Dependent Claim 60 stands rejected over the same prior art as independent Claim 54.

Anderson teaches away from combination with *Gibson. Anderson* purports to describe a eutectic or near-eutectic solder matrix, and in doing so, teaches away from having intermetallic components present at the claimed levels of 10% to 40%, by volume. For example, as noted in the context of Claims 20 and 39, an exemplary eutectic or near-eutectic Sn-Ag-Cu solder having 10 vol. % percent of a Cu_6Sn_5 intermetallic component has a total copper concentration of over 4.4 wt. %, and a melting temperature in excess of 310°C, which far exceeds the concentration of

copper and desired melting temperatures specified in *Anderson. Gibson* lacks any disclosure or suggestion of the processes of Appellants' claimed invention, namely of adding an intermetallic at greater than about 10 vol. % to a eutectic or non-eutectic solder matrix in the manner claimed. While *Gibson* describes higher volumetric amounts of intermetallic components, if such components were combined with *Anderson*, they would create a composition even father afield from the eutectic compositions with low melting points that fulfill the objectives of *Anderson.* As such, *Anderson* teaches away from combination with *Gibson.*

Importantly, nothing in either *Gibson* or *Anderson* describes or provides an apparent reason to arrive at a process that includes melting, cooling, and re-melting a solder composition, as recited in Claim 54. Neither *Anderson* nor *Gibson* describes heating the claimed mixtures of components to a temperature greater than the highest melting temperature of all of the individual components of the mixture to melt and form a non-solid mixture during the formation of the composite solder, such as recited in Claim 54. *Anderson* merely describes heating the solder to a melt pour temperature of about 300°C. Col. 6, l. 32. This temperature is insufficient to fully melt the elements of a Sn, Ag, Cu system, where the melting temperatures of Sn, Ag and Cu are about 232°C, about 962°C, and about 1085°C, respectively. As such, Claim 54 requires heating to at least 1085°C for the comparative Sn-Ag-Cu system, which is not described or suggested by *Anderson. Gibson* does nothing to remedy the deficiencies of the *Anderson* reference. The combination of *Anderson* and *Gibson* fails to render Claims 54 and 60 obvious and the rejection should be reversed.

Dependent Claims 34 and 35, which depend upon Claim 20, recite the intermetallic component being present from about 10 to about 20% by volume of the matrix solder. For all of the reasons set forth above for Claims 54 and 60, the invention of Claims 34 and 35 are not rendered obvious by the combination of *Anderson* with the *Gibson* reference. *Anderson* fails to

describe methods of making composite solders where the intermetallic components are present at 10% to 20% by volume. The *Gibson* article does not account for the deficiencies of the *Anderson* reference and their combination does not render the claimed invention obvious. As such, the rejection of Claims 34 and 35 should likewise be reversed.

VIII. CONCLUSION

In sum, the rejections of record are based on a flawed analysis of a flawed reference. When properly viewed in context of the entire art, *Anderson* does not teach a eutectic solder composition having intermetallics. Furthermore, even if *Anderson's* teachings are acceptable, arriving at the claimed invention from *Anderson* requires modifying the teachings of *Anderson* in a way contrary to its teachings, rendering compositions inoperable for the purposes sought by *Anderson*. In view of these deficiencies, Appellants, therefore, respectfully petition this Honorable Board to reverse the final rejection of the claims on each ground and to find that all claims are allowable.

Respectfully submitted,

Dated: June 16, 2008

By: ______________________
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IX. CLAIM APPENDIX

Copy of the Claims Appealed

1-19. (Cancelled)

20. A method for producing an *in-situ* composite solder having an intermetallic component, comprising the steps of:

(a) providing a mixture comprising the components of a eutectic or near-eutectic matrix solder and the components of an intermetallic component present at greater than or equal to about 10 volume % and less than or equal to about 95 volume %, wherein said intermetallic component is selected to have a density within 10% of a density of said eutectic or near-eutectic matrix solder;

(b) heating said mixture so as to melt all components of said mixture forming a non-solid mixture; and

(c) cooling said non-solid mixture at a rate sufficiently fast so as to form said intermetallic components having a particle size of less than about 10 microns, wherein said intermetallic components are homogenously distributed throughout said matrix solder to form the composite solder.

21. A method of Claim 20, wherein said intermetallic component comprises a transition metal.

22. A method of Claim 21, wherein said intermetallic component comprises a first row transition metal.

23. A method of Claim 22, wherein said intermetallic component comprises a metal selected from the group consisting of nickel, iron, copper, and mixtures thereof.

24. A method of Claim 23, wherein said intermetallic component comprises Cu_6Sn_5.

25. A method of Claim 23, wherein said intermetallic component comprises Ni_3Sn_4.

26. A method of Claim 23, wherein said intermetallic component comprises $FeSn_2$.

27. A method of Claim 21, wherein said intermetallic component comprises a metal which is a component of said matrix solder.

28. A method of Claim 20, wherein said matrix solder is a lead-free eutectic or near-eutectic solder.

29. A method of Claim 28, wherein said matrix solder is a binary or ternary solder.

30. A method of Claim 29, wherein said matrix solder is 96.5 Sn/3.5 Ag.

31. A method according to Claim 20, wherein said intermetallic components are less than 5 microns in size.

32. A method according to Claim 31, wherein intermetallic components having a particle size of less than about 5 microns are homogenously distributed throughout said matrix solder.

33. A method according to Claim 32, wherein intermetallic components having a particle size of less than about 2 microns are homogenously distributed throughout said matrix solder.

34. A method according to Claim 20, wherein said intermetallic component comprises from about 10% to about 20% by volume of said composite solder.

35. A method of Claim 34, wherein said intermetallic component comprises about 20% by volume of said composite solder.

36. A method according to Claim 20, additionally comprising, after said heating step (b) and prior to said cooling step (c), the steps of cooling said mixture to form a solid, and remelting said solid at a temperature sufficient to melt all components of said solid.

37. A method according to Claim 20, wherein said cooling is at a rate of at least about 100° C/second.

38. A method of Claim 20, wherein said cooling step comprises cooling by spat quenching, spray atomization, or by continuous casting into a solid form.

39. A method for producing an *in-situ* composite solder having an intermetallic component, comprising the steps of:

(a) providing a mixture comprising the components of a matrix solder and the components of said intermetallic component in amounts appropriate to form a solder having from about 10% to about 40% by volume of said intermetallic component, wherein said intermetallic component is selected to have a density within 10% of a density of said matrix solder;

(b) heating said mixture so as to melt all components of said mixture forming a non-solid mixture; and

(c) cooling said non-solid mixture at a rate sufficiently fast so as to form a composite solder wherein intermetallic components having a particle size of less than about 10 microns are homogenously distributed throughout said matrix solder.

40. A method of Claim 39, wherein said intermetallic component comprises a first row transition metal.

41. A method of Claim 40, wherein said intermetallic component comprises a metal selected from the group consisting of nickel, iron, copper, and mixtures thereof.

42. A method of Claim 41, wherein said intermetallic component comprises a compound selected from the group consisting of Cu_6Sn_5, Ni_3Sn_4, $FeSn_2$, and mixtures thereof.

43. A method of Claim 40, wherein said intermetallic component additionally comprises a metal which is a component of said matrix solder.

44. A method of Claim 39, wherein said matrix solder is a eutectic or near-eutectic binary or ternary solder.

45. A method of Claim 44, wherein said matrix solder is 96.5 Sn/3.5 Ag.

46. A method of Claim 39, wherein said cooling step comprises cooling by spat quenching, spray atomization, or by continuous casting into a solid form.

47. A method according to Claim 39, wherein said solder is lead-free.

48. A method according to Claim 39, wherein said intermetallic components are less than 5 microns in size.

49. A method according to Claim 48, wherein intermetallic components having a particle size of less than about 5 microns are homogenously distributed throughout said matrix solder.

50. A method according to Claim 49, wherein intermetallic components having a particle size of less than about 2 microns are homogenously distributed throughout said matrix solder.

51. A method according to Claim 39, wherein said intermetallic component comprises from about 10% to about 20% by volume of said composite solder.

52. A method according to Claim 39, wherein said cooling is at a rate of at least about 100° C/second.

53. A method according to Claim 39, additionally comprising, after said heating step (b) and prior to said cooling step (c), the steps of cooling said mixture to form a solid, and remelting said solid at a temperature sufficient to melt all components of said solid.

54. A method for producing an *in-situ* composite solder having an intermetallic component, comprising the steps of:

(a) providing a binary or ternary eutectic or near eutectic matrix solder;

(b) heating a mixture of said matrix solder with the components of an intermetallic component comprising a first row transition metal, at a temperature greater than the highest melting temperature of all of the individual components of said mixture so as to form a non-solid mixture;

(c) rapidly cooling said non-solid mixture; wherein said composite solder comprises from about 10% to about 40% by volume of said intermetallic component, said intermetallic component comprises at least one element present in said matrix solder; said intermetallic component comprises particles having a particle size of less than about 10 microns homogenously distributed throughout said composite solder, and said intermetallic component is selected to have a density within 10% of a density of said matrix solder;

(d) heating said composite solder to a temperature that is greater than a melting point of said matrix solder and less than a melting point of said intermetallic component, wherein said heating melts only said matrix solder; and

(e) cooling and solidifying said composite solder to form a solder joint, wherein said composite solder has a greater solder joint strength, creep resistance, and fatigue resistance than a comparative solder joint formed from a eutectic or near-eutectic solder.

55. A method of Claim 54, wherein said particle size is less than 5 microns.

56. A method of Claim 54, wherein said particle size is less than 2 microns.

57. A method of Claim 54, wherein said intermetallic component comprises a metal selected from the group consisting of nickel, iron, copper, and mixtures thereof.

58. A method of Claim 57, wherein said intermetallic component comprises a compound selected from the group consisting of Cu_6Sn_5, Ni_3Sn_4, $FeSn_2$, and mixtures thereof.

59. A method of Claim 58, wherein said matrix solder is 96.5 Sn/3.5 Ag.

60. A method of Claim 54, wherein said intermetallic particles comprises about 10% to about 20% by volume of said composite solder.

61. A method of Claim 54, wherein said cooling step comprises cooling by splat quenching, spray atomization, or by continuous casting into a sold form.

62. A method according to Claim 54, additionally comprising, after said heating step (b) and prior to said cooling step (c), the steps of cooling said mixture to form a solid, and remelting said solid at a temperature sufficient to melt all components of said solid.

X. EVIDENCE APPENDIX

37 C.F.R. §1.132 Declaration of Co-Inventor Thomas R. Bieler executed on November 19, 2006 and submitted with the Amendment Under 37 C.F.R. 1.111(a) and Petition for Extension of Time on December 12, 2006.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.:	10/730,398
Filing Date:	12/8/2003
Applicant:	Bieler et al.
Group Art Unit:	1742
Examiner:	Sikyin Ip
Title:	METHODS FOR PRODUCING LEAD-FREE IN-SITU COMPOSITE SOLDER ALLOYS
Attorney Docket:	6550-000013/COA

DECLARATION UNDER 37 C.F.R. §1.132

1. I am an associate professor in the Department of Chemical Engineering and Materials Science at Michigan State University. I have a Ph.D. from the University of California in Materials Science, a M.S. in Ceramic Cngineering from the University of Washington, and a B.A. in Applied Mechanics from the University of California.

2. I am a co-inventor of U.S. Patent Application Serial No.10/730,398 as identified above and of the subject matter described and claimed therein, including Claims 20-62. The claimed methods begin with a eutectic or near-eutectic solder composition, and add intermetallic components, to form a mixture which is compositionally altered and far-removed from a eutectic or near-eutectic solder.

3. This declaration is being presented to traverse the rejections asserted in the Office Action mailed on August 18, 2006 and to establish factual evidence in support of patentability of the presently claimed invention.

4. I have reviewed and am familiar with the references cited in the August 18, 2006 Office Action, including:

A) U.S. Patent No. 5,527,628 to Anderson et al.

5. I have reviewed and am familiar with the following additional references:

B) Miller, et al., "A Viable Tin-Lead Solder Substitute: Sn-Ag-Cu," Journal of Electronic Materials, vol. 23, no. 7, pp. 595-601 (1994).

C) Moon, et al., "Experimental and Thermodynamic Assessment of Sn-Ag-Cu Solder Alloys," Journal of Electronic Materials, vol. 29, no.10, pp. 1122-1136 (2000).

4. U.S. Patent No. 5,527,628 to Anderson et al. ('628 patent) describes a lead-free solder having a eutectic point of about 217°C for a composition of 93.6 Sn - 4.7 Ag - 1.7 Cu (wt.%). The Miller Article (B), authored by some of the inventors of the '628 patent, describes a lead-free solder that has the same composition as set forth in '628. See for example, Abstract, p. 598 Col. 1 to p. 599 Col. 1.

5. The '628 patent sets forth erroneous compositional ranges, including an erroneous eutectic composition for the Sn-Ag-Cu system. This error has been recognized by those of skill in the art, including various third parties. The Moon article (C) acknowledges this error and further states on Pages 1122 to 1123 that "[p]reliminary thermodynamic calculations performed by one of the authors [ ] and reported by Miller et al. [B] predicted a ternary eutectic...an error was made in the conversion from atomic to weight % conversion by Miller et al."

6. The Moon article (C) reports that the ternary eutectic composition for the Sn-Ag-Cu system is 3.5 wt. % Ag - 0.9 wt. % Cu – 95.6 wt. % Sn, with a eutectic temperature of approximately 217°C, which is now widely accepted in the art.

7. As such, those of skill in the art recognize that the compositional ranges for the eutectic Sn, Ag, and Cu system set forth in the '628 patent are incorrect and the '628 patent does not teach a eutectic lead-free solder composition.

8. A low melting point lead-free solder alloy has a composition corresponding to eutectic or near-eutectic solder where virtually the entire solder alloy melts easily into a liquid phase at soldering re-flow temperatures. Those of skill in the art recognize that adding components to a eutectic composition

alters the alloy such that it is no longer eutectic or near-eutectic and thus will no longer melt to form a solely liquid phase.

9. The '628 patent is not compositionally similar to the claimed invention. The claimed method provides a eutectic solder (as a matrix) and then further adds components of an intermetallic compound. After heating the mixture to melt the eutectic solder and the intermetallic compounds, the non-solid mixture is cooled to homogeneously distribute unmelted intermetallic components having a particle size of <10 μm through the eutectic or near-eutectic solder matrix. The '628 patent is focused on the true eutectic (all liquid) and thus does not describe or suggest such a method to those of skill in the art.

10. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Dated: ____19 November 2006______

Thomas R Bieler

Thomas R. Bieler

XI. RELATED PROCEEDINGS APPENDIX

None.